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ABSTRACT

This study examined the extent to which teacher verbal behavior in the classroom reflected the type and level of cognitive processes as conceptualized by Sternberg's componential theory of intelligence. The frequency and distribution of these behaviors within and across disciplines was also explored. Twenty-three teachers in four high schools were videotaped in the classroom and the frequencies of cognitive behaviors across the disciplines of mathematics, science, English, and social studies were recorded and analyzed. Results of the analysis revealed significant main effects for field of study and components, and significant interactions for components by field. Findings are discussed in terms of teacher cognitive behavior. The study did not attempt to judge patterns of teacher-pupil interactions. (Author/MT)

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# A Survey of Teacher Cognitive Behavior in the Classroom

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A Survey of Teacher Cognitive Behavior

in the Classroom


## Abstract

This study examined the extent to which teacher verbal behavior in the classroom reflected the type and level of cognitive processes as conceptualized by Sternberg's componential theory of intelligence. Twenty-three classrooms in four high schools were videotaped and the frequencies of of cognitive behaviors across four subjects were recorded and analyzed. Results of the analysis revealed significant main effects for subjects, and components and significant interactions for components by subject. Findings are discussed in terms of impact of teacher cognitive behavior on student cognitive functioning.

## A Survey of Teacher Cognitive Behavior in the Classroom

The investigation of the quality of teacher cognitive behavior in the classroom is not new. For the past two decade, numerous studies, influenced by concepts in psychology, have sought to assess the type and level of such behaviors across disciplines and grade levels (see Dunkin & Biddle, 1974; Redfield & Rousseau, 1981; Winne, 1979 for reviews). An assumption in many of these investigations is the notion that if teachers engage in behaviors that are reflective of cognitive processes, and to encourage students to emulate them then student cognitive behaviors might be enhanced. This idea is similar to that concerning the role of teachers in participant modelling instruction (Bandura, 1977) or in scaffolded instruction (Applebee & Langer, 1983; Palincsar & Brown, 1984; Wood et al., 1976) and underscores the importance of teachers as facilitators of student cognitive growth.

In an earlier period, two paradigms served as the conceptual frameworks for research in this area: The Taxonomy of Educational Objectives- The Cognitive Domain (Bloom et al., 1956) and Guilford's model for the "Structure of Intellect" (1956, 1970). Bloom and his associates developed a taxonomy of behaviors presumed to be cognitive outcomes of schooling, and they hierarchically categorized behaviors as knowledge, comprehension, application, analysis, evaluation and synthesis. Investigators of the application of these concepts in the

classroom reported that process behaviors at the knowledge level occurred more frequently than in any other category ( Mood, 1972; Murray & Williams, 1971; Wilson, 1969; Wood, 1970).

Researchers have also employed concepts from Guilford's "Structure of the Intellect" in analyzing teacher classroom behaviors. According to Guilford (1956), demonstration of intellectual ability consists of the use of a particular type of cognitive operation upon a particular type of content to produce a particular type of product. He further distinguished five types of operations (cognition, memory, divergent production, convergent production, and evaluation) as being particularly important in the performance of an intellectual act. Analysis of classroom behaviors in terms of the type and level of operations revealed that teachers engaged most frequently in memory-related verbal behavior (Gallagher et al., 1970) and their classroom exchanges were more convergent than divergent (Hudgins & Ahlbrand, 1967; Medley, 1966).

Within the last decade, there has been a renewed interest in cognitive processes. This interest has been guided by an information- processing perspective on intelligence. Cognitive theorists who espouse this view propose that, in part, the psychological bases of intelligent behavior can be understood in terms of components of information processing (Campione & Brown, 1979; Carroll, 1976; Hunt, 1978; Jensen, 1979; Newell & Simon, 1972; Pellegrino & Glaser, 1979; Snow, 1979; Sternberg, 1977, 1979, 1986). Although the researchers disagree as to the exact set of components accounting for the latent abilities that

underlie intelligent behavior, they all view the "component" as the basic unit for understanding individual differences in intelligence (Simon, 1972; Sternberg, 1977). The component is an elementary information process that operates upon an internal representation of objects or symbols. Components may be distinguished from one another on the basis of type, level and function performed in an intellectual act. One version of an information processing theory that may have implications for the assessment of teacher cognitive behavior is Sternberg's ( 1977, 1979, 1980, 1986) componential theory of intelligence. Sternberg views processes as being of three types: metacomponents, performance components, and knowledge-acquisition components.

Metacomponents are higher order control processes that are used in planning and decision making in problem solving. Sternberg considers six metacomponents as of particular importance in a problem- solving situation:

(a) defining the nature of the problem;
(b) selecting the steps needed to solve the problem;
(c) selecting a strategy for ordering components of problem solving;
(d) selecting a mental representation of information in the problem;
(e) allocating resources (setting speed-accuracy tradeoffs in problem solving;
(f) monitoring and evaluating problem- solving performance.

Performance components are processes involved in actually doing the task. Although it is impossible to generate an exhaustive list of performance processes, Sternberg has isolated five components that have been found to underlie a wide range of inductive

reasoning and problem solving tasks:

(a) encoding stimuli (storing information in working memory and retrieving information from long- term memory that might be potentially relevant for solving the problem;
(b) inferring the relation between two or more stimuli;
(c) mapping (recognizing a higher order relation between two lower-order relations);
(d) applying a relation that has been previously inferred to establish an ideal answer;
(e) discriminating among options so as to choose the best although not ideal option.

Knowledge- acquisition components are processes an individual uses in learning new and contextual information, remembering previously learned information and transferring information learned from one context to another. They include processs such as:

(a) selective encoding: sifting out relevant from irrelevant information;
(b) selective combination: grouping information around an organizing concept or forming an integrated picture of a phenomenon;
(c) selective comparison: relating newly acquired information to old information or information acquired in the past.

As in previous research, these concepts can be applied to the classroom as well as to the individual mind and a determination can be made as to the extent to which teachers' verbal interactions with students reflect these cognitive processes. Given the importance attached to teaching thinking in the classroon, the teacher's mediational role in stimulating cognitive processes in learners cannot be overstated. The type and level of cognitive behaviors and the frequency with which teachers use them in the classroom may be critically related to the quality of cognitive behaviors engaged in by learners. It is from this viewpoint that in this study, we use Sternberg's

componential model of intelligence to analyze teachers' cognitive behavior in the classroom. Specifically, we seek answers to two questions about teachers' cognitive behavior:

(1) What types and levels of cognitive processes characterize teachers verbal behaviors?

(2) What is the frequency and distribution of occurrences of these behaviors within and across disciplines?

## Method

### Subjects

Participants were selected from four public high schools (three from inner-city New York and the other from New Haven, Connecticut). A total of 15 male and 8 female teachers who taught classes in grades 9 through 11 volunteered for the study. Of the participants, 4 taught classes in Mathematics, 5 in Science, 6 in English, and 8 in Social Studies.

### Instrumentation

Teachers' classroom behaviors were videotaped and later analyzed in terms of Sternberg's (1977, 1979, 1980) theory of the processes underlying intellectual behavior. During each lesson, the teachers' behaviors were coded by two coders using an observation system that categorized cognitive behaviors into four classes: metacomponents, performance components and knowledge-acquisition components. Cognitive behavior was

operationally defined as any verbal behavior by which the teacher directed, reinforced, called attention to or enabled students to process information. Included in the taxonomy was any behavior by which the teacher modelled or elicited process behaviors from students. The observation form used for the study is shown in Figure 1.

Training sessions were held in which two video-tapes of classroom teaching in Mathematics and Science were analyzed by observer-trainees. The purpose of the training was to establish a satisfactory observer agreement that the behaviors observed corresponded to the various items in the instrument. The formula for observer reliability was computed as the agreements (A) divided by the agreements plus the disagreements (A+D).

## Procedure

Each teacher was videotaped for a single 40-minute period. An earlier observation of a random sample of tapes revealed very little instructionally-related interaction between teacher and pupils during the first and last five minutes of class . On the basis of this observation, it was decided to record teacher behaviors from the sixth to the twenty- fifth minute of classroom time. Each 20-minute observation period was subdivided into 4 separate 5-minute recording periods and teacher cognitive behaviors were recorded within each of these periods. The observer recorded behavior as it occurred by placing a check beside each item of teacher behavior in the appropriate column. Any process behavior was checked once in a given column regardless

of the number of times that behavior occurred within the 5-minute recording period. Thus, the range of scores for each type of behavior within any level of process was from zero to four. Those behaviors that did not fit within Sternberg's conceptual framework of cognitive proceses were ignored. At the end of the 20-minute period, a tally was made of the number of relevant teacher cognitive behaviors that occurred during that observation period.

Observer Reliability. Inter-observer reliability figures were calculated on the three categories of process behaviors using the formula: agreements divided by the agreements plus the disagreements. They were as follows:- .90 for Metacomponents; .70 for Performance components; and .84 for Knowledge- Acquisition components, with an average of .81 when the three categories were combined.

## Results

Table 1 present the means and standard deviations of the scores of the three components by subject. For each level of component, each teacher's score was added and divided by the number within level. There were six process dimensions at the metacomponential level, five at the performance level and three at the knowledge-acquisition level. To determine if there were significant differences among scores we performed a one-way repeated measures analysis of variance. Analyses revealed significant main effects for subject, $F(1, 22) = 5.01$, $p < .01$, and components, $F(1, 22) = 3.59$, $p < .001$, and significant interactions for components by subject, $F(2, 21) = .94$, $p < .001$.

In general, Mathematics and Science teachers tended to use more metacomponents and performance components than English and Social Studies teachers. However, all teachers, irrespective of subject area, tended to use the same number of knowledge-acquisition components.

Table 2 and 3 present the mean and standard deviations of scores of component type by subject. Although teacher verbal behaviors did seem to reflect different levels of cognitive processes, there was some uneveness of distribution within levels by discipline. For example, at the metacomponential level, in general, there was a greater use of components in Mathematics and Science. The use of defining the problem occurred the most and allocating resources occurred the least. Monitoring occurred most frequently in Mathematics and selecting steps and strategies occurred least in English and Social Studies. At the performance component level, more behaviors occurred in Mathematics, Science and Social Studies with most frequent occurrence in encoding and inferring processes. Mapping occurred most frequently in Science and application occurred least in English and Social Studies. Within knowledge-acquisition components there were fewer occurrences in selective encoding than either selective combination or selective comparison behaviors.

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Insert Tables 2 and 3 about here

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## Discussion

In general, teachers engage in the kinds of cognitive behaviors as conceptualized by Sternberg's system for understanding intelligence. In each discipline, the highest frequency of process behaviors occurred at the knowledge-acquisition level and the lowest at the performance- components level. Only in Mathematics was there a high frequency of occurrence of behavior at the metacomponential level. It was unclear whether the source of infrequency of some processes was in any way related to the nature of the subject matter under investigation or the unawareness on the teacher's part that these processes do underlie competent student performance in almost any discipline. For example, the relative infrequency of occurrence of process behaviors in English and Social Studies as compared to Mathematics and Science suggest two possibilities. First, it may well be that there is a lack of knowledge and/ or expertise in making processes explicit through teaching among the teachers observed in the humanities. Second, the nature of the subject matter in English and Social Studies may require less of the logical and sequential progression of thought for problem solving than do Mathematics and Science.

Although it was encouraging to observe teacher cognitive behavior in the classroom, it should be remembered that mere verbalization of process statements by teachers did not necessarily imply that such processes were effectively communicated to students. It was not the purpose of this study to identify the patterns of teacher-pupil interactions. It was somewhat

disconcerting, nevertheless, to observe the context in which teacher behaviors were recorded. On numerous occasions, teachers recitated information about process and in those instances in which they solicited student involvement to identify or describe their behavior processually, student participation was limited to low-level responses. The level of teacher-student interaction was also very low. If teacher cognitive behaviors are to influence the way students think, then some mechanism will be needed whereby the type and level of teacher-pupil process interaction occur in a deliberate and systematic manner. During an instructional sequence, teachers would need to consider the context in which different processes ought to be used and the most appropriate methodology for communicating them to students. Furthermore, in their verbal exchange with students, teachers should determine when to model process, when to make explicit explanation of process or when to elicit process statements from students. In addition, teachers should provide reinforcing and corrective feedback on students' correct and incorrect responses, if their cognitive growth and development are to be enhanced in the classroom.

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Table 1

Means and Standard Deviations for Subjects by Components

| Subject | Metacomponents | | Performance components | | Knowledge-acquisition components | | |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Total |
| Math | 2.54 | .57 | 1.75 | .44 | 2.17 | .69 | 2.15 |
| Science | 1.93 | .67 | 2.04 | .70 | 2.73 | .49 | 2.24 |
| English | .36 | .22 | 1.03 | .29 | 2.06 | .49 | 1.15 |
| Social Studies | .94 | .44 | 1.28 | .53 | 1.79 | 1.07 | 1.33 |

Table 2

Means and Standard Deviations of Component Types by Subject

Metacomponents

| SUBJECT | DEF | STEPS | STRAT | REP | RES | MON |
|---|---|---|---|---|---|---|
| Math | | | | | | |
| M | 3.25 | 3.00 | 3.00 | 2.75 | .50 | 2.75 |
| SD | .96 | .82 | 1.15 | .50 | .58 | .50 |
| Science | | | | | | |
| M | 3.20 | 2.00 | 2.40 | 3.00 | 0.00 | 1.00 |
| SD | .84 | 1.22 | .55 | 1.22 | 0.00 | .71 |
| English | | | | | | |
| M | 1.83 | .17 | .17 | 0.00 | 0.00 | 0.00 |
| SD | .98 | .41 | .41 | 0.00 | 0.00 | 0.00 |
| Social Studies | | | | | | |
| M | 2.25 | .38 | .38 | 1.63 | 0.00 | 1.00 |
| SD | 1.04 | .52 | .52 | 1.06 | 0.00 | .76 |

Peformance Components

| Subject | Encoding | Inferring | Mapping | Appli-cation | Justifi-cation |
|---|---|---|---|---|---|
| Math | | | | | |
| M | 2.75 | 3.00 | .75 | 2.25 | 0.00 |
| SD | 1.26 | .82 | .96 | .50 | 0.00 |
| Science | | | | | |
| M | 3.40 | 3.00 | 1.80 | 2.00 | 0.00 |
| SD | .89 | 1.22 | 1.10 | .71 | 0.00 |
| English | | | | | |
| M | 2.67 | 2.50 | 0.00 | 0.00 | 0.00 |
| SD | .52 | 1.05 | 0.00 | 0.00 | 0.00 |
| Social Studies | | | | | |
| M | 2.88 | 2.50 | .37 | .63 | 0.00 |
| SD | .99 | 1.41 | .52 | .52 | 0.00 |

Note. DEF. = defining the problem; STEPS = selecting steps; STRAT = selecting a strategy; REP = Representing information; RES = allocating resources; MON = monitoring solution.

Table 3

Means and Standard Deviations of Component Types by Subject

Knowledge-acquisition Components

| Subjects | Selective encoding | Selective combination | Selective comparison |
|---|---|---|---|
| Math | | | |
| M | 1.50 | 3.00 | 2.00 |
| SD | 1.29 | .82 | 1.41 |
| Science | | | |
| M | 2.00 | 2.60 | 3.60 |
| SD | .71 | .89 | .55 |
| English | | | |
| M | .50 | 3.00 | 2.67 |
| SD | .55 | .63 | 1.03 |
| Social Studies | | | |
| M | .50 | 2.50 | 2.38 |
| SD | .54 | 2.74 | 2.65 |